# A new laboratory test chamber for the determination of diffusive sampler performances

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# A NEW LABORATORY TEST CHAMBER FOR THE DETERMINATION OF DIFFUSIVE SAMPLER PERFORMANCES

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## ABSTRACT

A new laboratory test chamber has been developed at INERIS for the determination of diffusive sampler performance. It consists in a loop made of glass, stainless steel and PTFE containing the reference atmosphere where diffusive samplers are exposed. It is possible to accommodate several samplers simultaneously and simulate various environmental conditions such as temperature, wind speed, wind direction, humidity, atmosphere composition, total pressure and exposure duration. All working parameters are continuously monitored.

It is shown that certain environmental conditions can deeply affect diffusive sampler performances. Thanks to the technical solutions adopted for its design, this chamber allows the determination of diffusive sampler performance in a wide range of experimental conditions in compliance with the new standards for the monitoring of ambient air by diffusive means.

## INTRODUCTION.

The assessment of ambient air quality by diffusive samplers, has been expanding continuously especially after the publication of the EC Air Quality Framework Directive. Diffusive samplers can be seen today as cost effective, sensitive and reliable tools for the assessment of personal exposure and air quality in both indoor and outdoor environments.

Standardisation groups CEN/TC 264 WG11 and WG13 have been working in two important standards (ref. 1-2). These standards, should provide the user of diffusive samplers with guidance and standardised procedures to make the best possible use of these devices.

Part III of the EN 13528 standard specifies that though performances of a diffusive sampler can be determined theoretically, it is a good practice to determine this experimentally in an exposure chamber where environmental conditions in which the sampler is intended to be used can be reproduced.

Exposure chambers should be able to:

-Accommodate at least several samplers for simultaneously exposure
-Produce a continuos reference atmosphere for a duration up to several weeks
-Simulate variable wind speeds
-Vary humidity and temperature
-Provide equal loading conditions for all samplers being exposed.

## INERIS DEVELOPMENT

An exposure chamber has been developed at INERIS for the determination of diffusive sampler performances. See fig. 1.

Basically, it consists in a loop made of glass, stainless steel and PTFE containing the reference atmosphere where diffusive samplers are exposed.

The main characteristics of the chamber are:

*Dimensions:*
-Exposure zone D= 300mm, h= 700mm
-Overall high H= 2.5m
-Total weight W= 450 kg (aprox.)

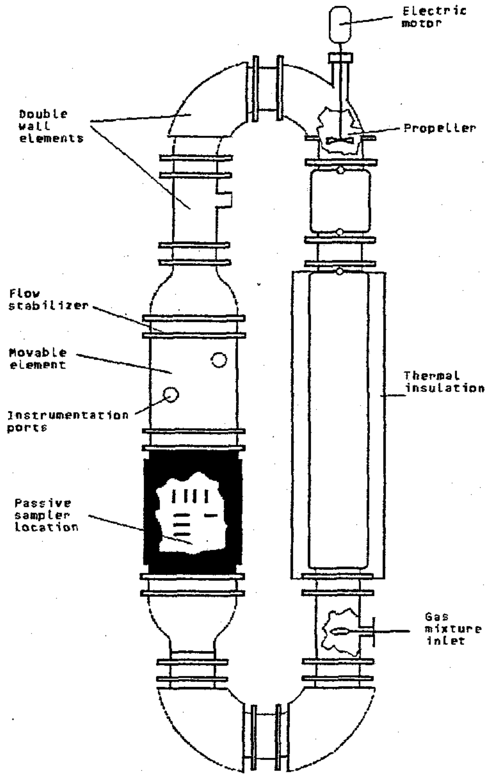


Fig. 1

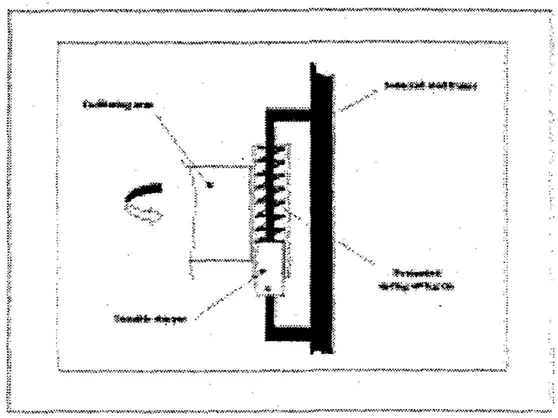

Fig. 2

*Supports:*
The chamber has been installed vertically and is supported by a soldered steel frame.
There is a movable section that can swing, leaving access to the exposure area. An oscillating arm that is fitted with a preloaded spring (fig. 2) holds this movable section. This mechanical arrangement facilitates the opening of the chamber for the introduction or the removal of the samplers. These samplers are attached to a basket made of stainless steel

*Gas mixtures:*
The contaminated atmosphere for the exposure is prepared separately by continuous dilution of a more concentrated mixture. This dilution is performed with the help of mass flow meters. Humidity is added by passing part of the dilution gas through a bath of HPLC quality water maintained at constant temperature. Typical concentrations of gas mixtures are in the ppb range; theoretically however, any level of concentration can be reproduced.
The diluted gas mixture is introduced into the chamber at a flow rate of one to several litres per minute in order to replace the total volume of the chamber (150L) several times a day and to insure that there is no significant depletion of the mixture concentration down stream the exposure area. This is particularly important when exposing samplers that have high uptake rates.

*Wind speed:*
Any passive sampler has to be implemented with a device dedicated to prevent turbulent diffusion inside the sampler air gap. This "wind effect", can be controlled by adjusting the speed of a "model aeroplane " propeller located inside the chamber. Since the flow path is not straight, there is an undesirable jet effect up stream the exposure zone. This difficulty has been overcome using a flow stabiliser. This device is a drilled polished

stainless steel plate. Down stream this plate, the flow is still turbulent but all samplers are exposed to similar wind conditions.

*Temperature:*
One of the most attractive features of this chamber is the possibility to work in a wide range of temperatures, typically from –10°C to +50°C. This can been achieved by the use of double wall elements made of glass. A fluid is heated or cooled down in an external conditioner and drawn though the double walls of the entire device. The necessary thermal insulation is composed of 52 special jackets made of polyurethane foam, Teflon and aluminium.

*Monitoring:*
All working parameters are continuously monitored:

Temperatures, by Pt 100 probes.
Humidity, by a capacity probe ( Hanna Instruments HI 916010 C ).
Wind speed, by Annubar type probe (Diamond II, Dielerich Standard USA ).
Total pressure, by an electronic manometer ( Furness Ltd. ).
Gas mixture flow rate, by mass flow meters ( Tylan type).
Gas mixture composition: variable depending on the compounds of interest e.g. Automatic GC+FID for hydrocarbons, Chem. Lum. Monitor for NO2, etc.

## VALIDATION TEST

Several Perkin Elmer type samplers (RPE) packed with carbotrapB have been tested under the following conditions:

Number of samplers n=9
Type: RPE carbotrap B
Temperature: 20°C
Humidity: 50 %
Pressure: 1 at
Duration: 5.7 days
Gas mixture: benzene in synthetic air
Concentration generated: 4.19 µg/m3

After thermal desorption of the samplers and analysis of the benzene sampled during the exposure, uptake rates were calculated. Results are presented on table 1.

**Table 1**. RPE tubes exposed to a concentration of 4.19 µg/m3.
*(V and H stand for vertical and horizontal respectively)*

| Tube number | Position in the chamber | Uptake rate ml/min |
|---|---|---|
| A60829 | 7V top | 0.42 |
| A60699 | 4H middle | 0.42 |
| A49068 | 3V top | 0.43 |
| A56116 | 2H bottom | 0.43 |
| A57629 | 4V top | 0.43 |
| A47625 | 5V top | 0.41 |
| A31749 | 7 H middle | 0.44 |
| A73374 | 6 V middle | 0.41 |
| A35691 | 1 V top | 0.41 |
| | | |
| | **Average (STD%)** | **0.42 ( 2.9 )** |

The values of the uptake rates obtained in this experiment have been compared with those deduced from an other test carried out with the same samplers under the same conditions using the NPL facility in the UK (Ref.3). The difference observed on the average was 12.5%

## CONCLUSIONS

The low relative standard deviation observed (2.9%), shows that samplers were exposed to very similar conditions in the exposure area. Thanks to the technical solutions adopted for its design, this chamber, allows the determination of diffusive sampler performance in a wide range of experimental conditions in compliance with the new standards for the monitoring of ambient air by diffusive means.

*Acknowledgements.*
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*References.*
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